

A photograph of a rocket launch at dusk. The rocket is ascending vertically, leaving a massive, bright plume of white smoke and fire that reaches high into the sky. The sky is filled with scattered clouds, some of which are illuminated by the light from the launch. In the foreground, the silhouettes of people and structures are visible against the darkening sky. A large, rectangular building is on the right side, and a flagpole with a flag is visible near the base of the rocket. The overall scene is dramatic and captures the power of space exploration.

Space Travel of the Future

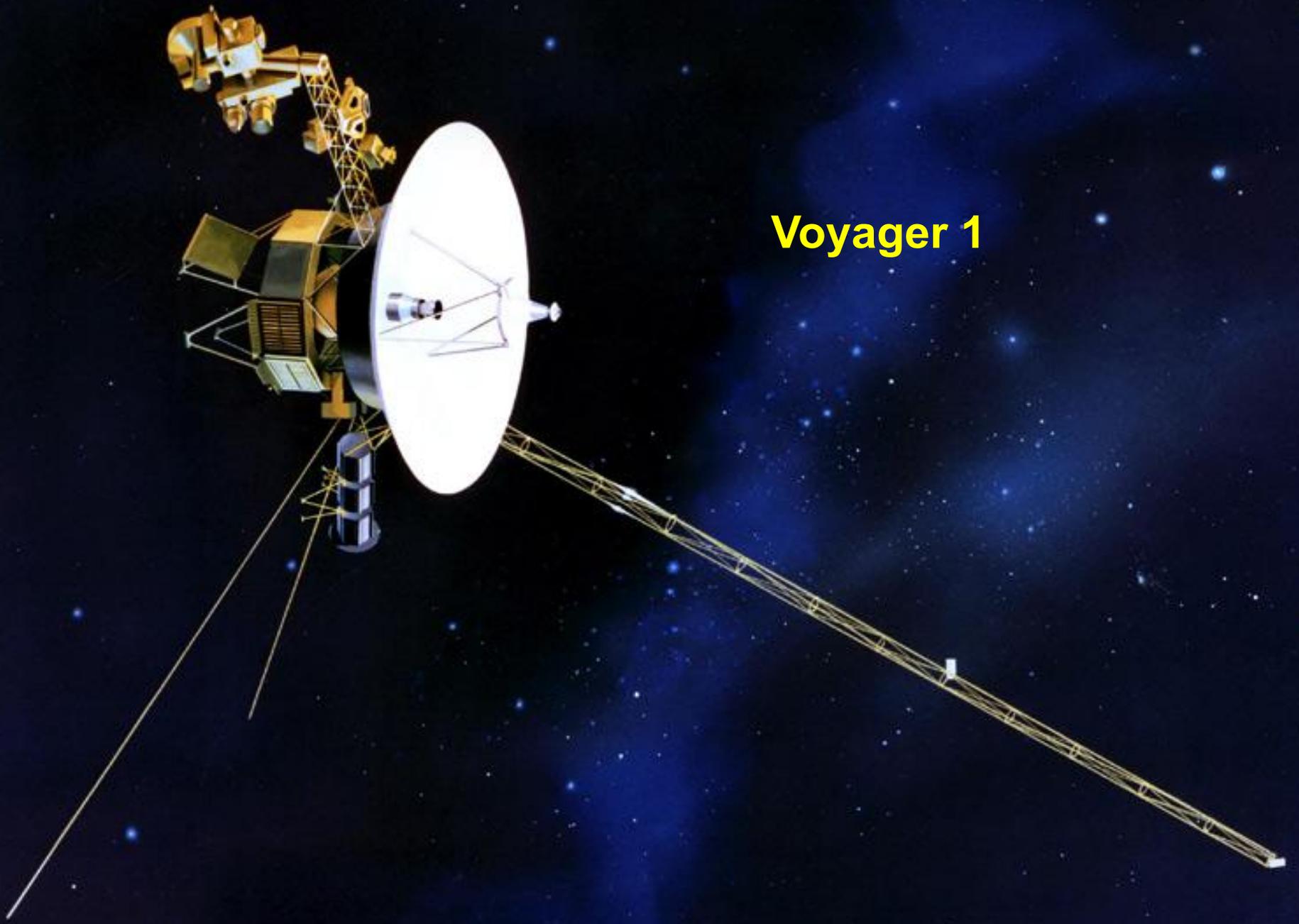
WOPAT #279

What I'm going to talk about:

- **Interplanetary travel**
- **Interstellar travel**
- **Intergalactic travel**
- **Faster than light travel**

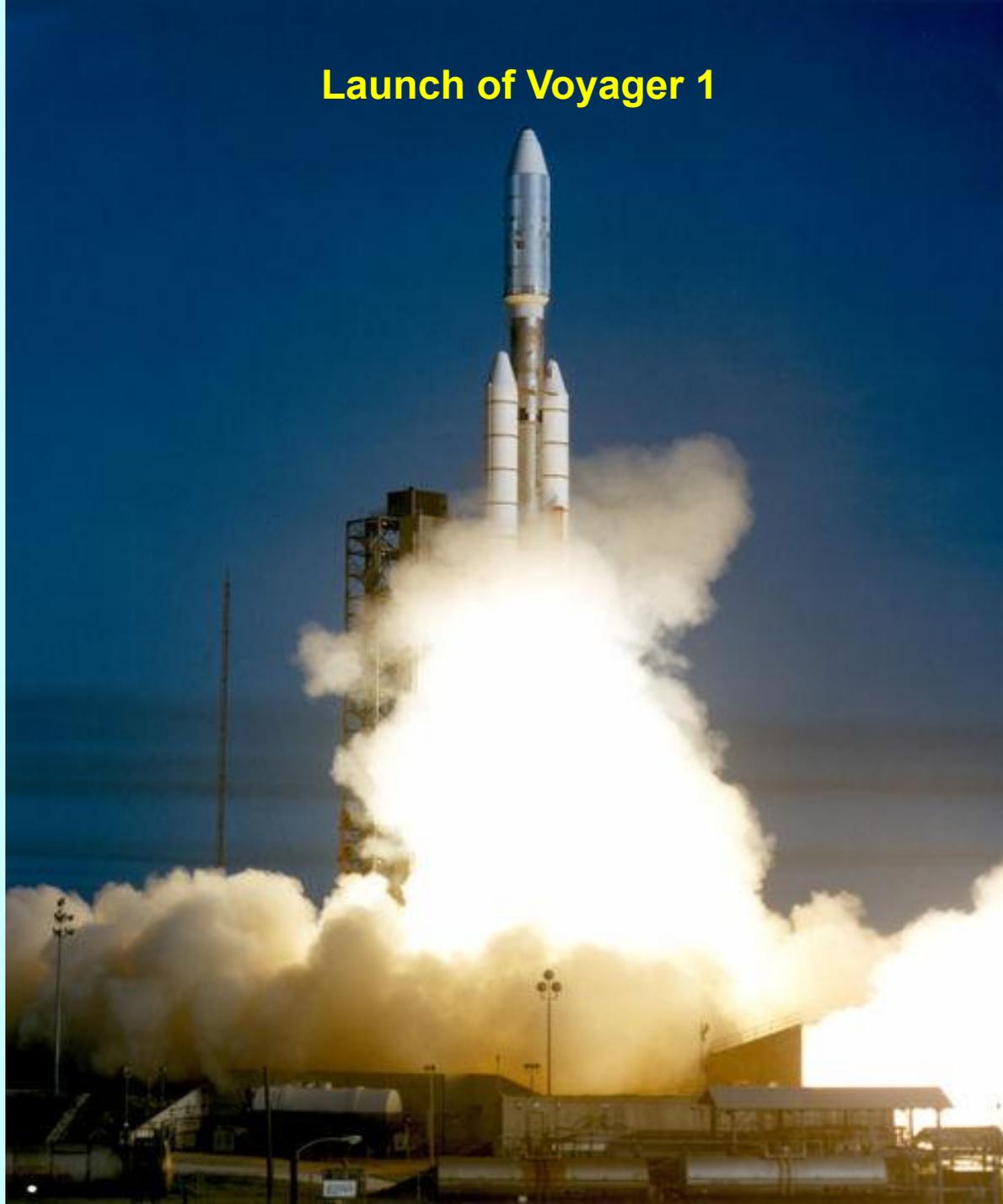
Space travel in the solar system

- Current accomplishments:
 - Voyager 1: farthest manmade object from Earth at 113 AU
 - Will remain powered until ~2025
 - Used gravity assists
 - Manned missions to the Moon
 - Saturn V rocket launches modular craft that docks on Moon
 - NASA's Constellation Program would have sent people to Mars - cancelled

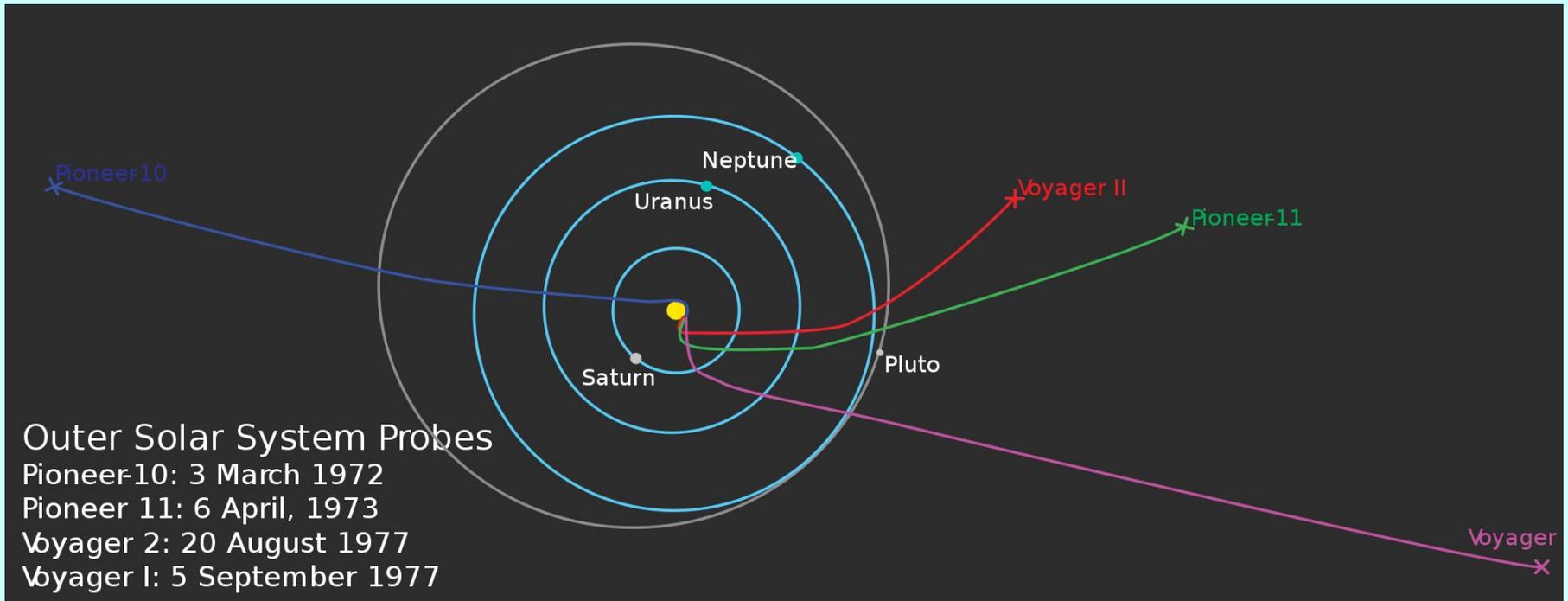


Voyager 1

Launch of Voyager 1

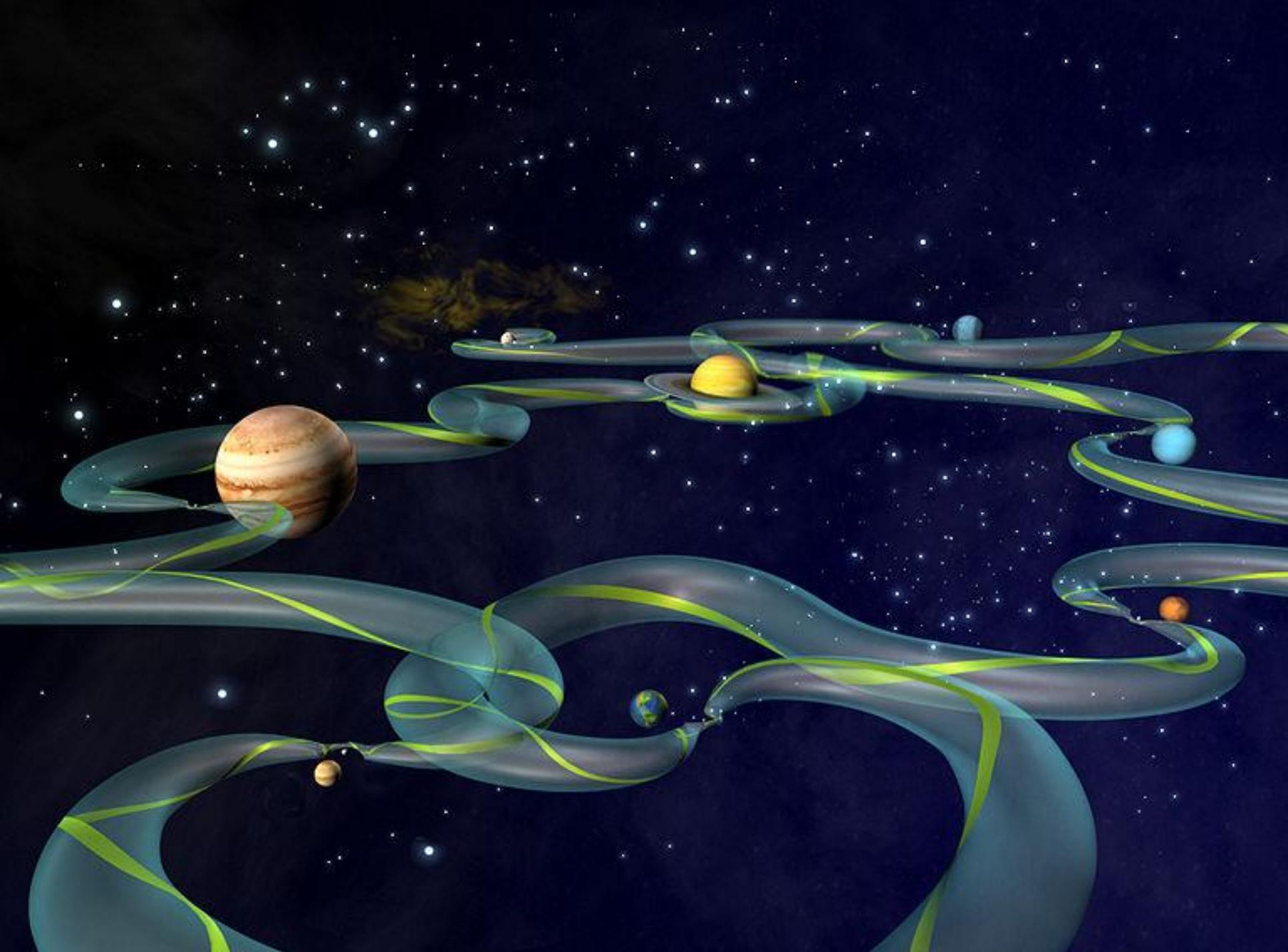


Flight Paths of Farthest Probes



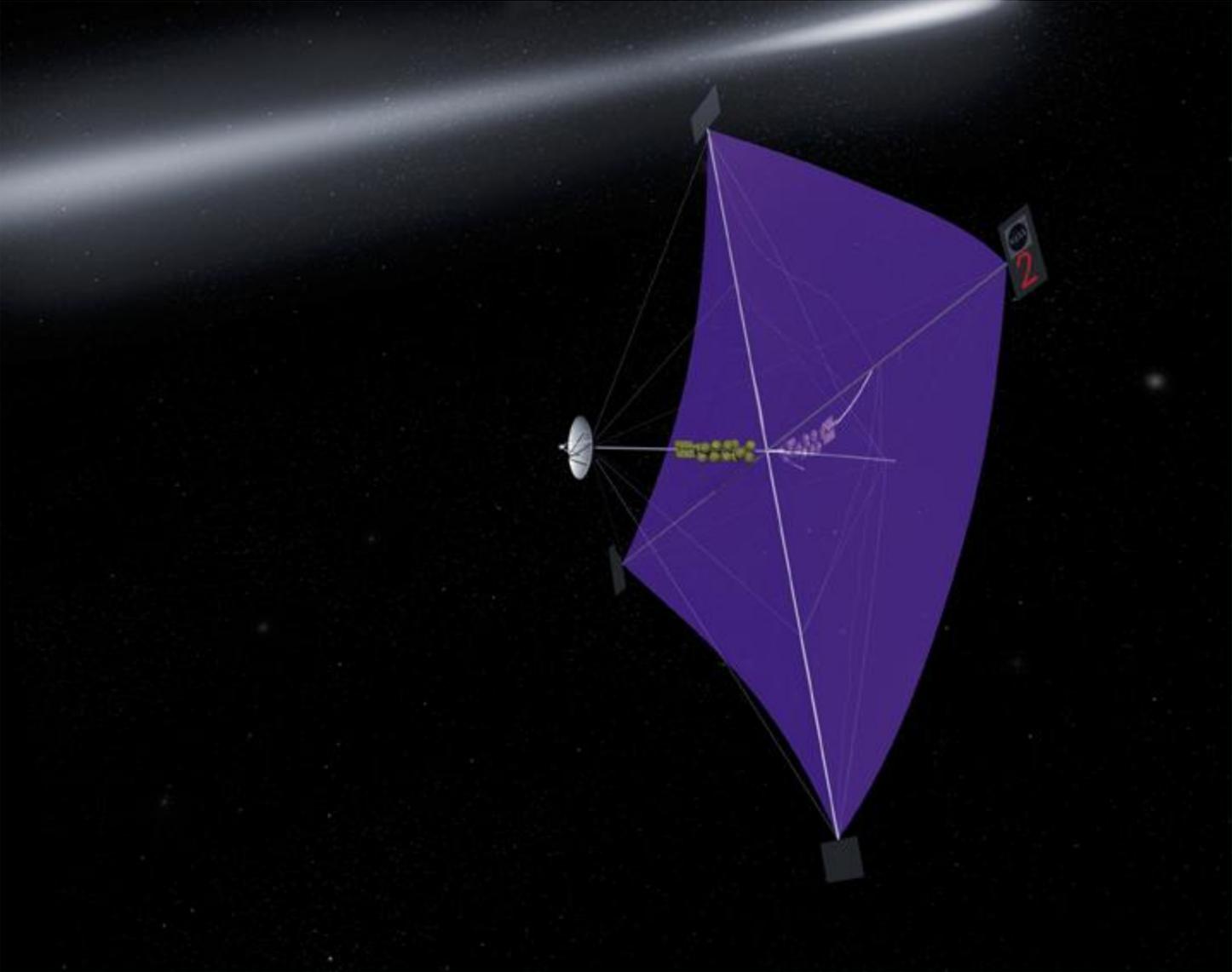
Future of Solar System travel

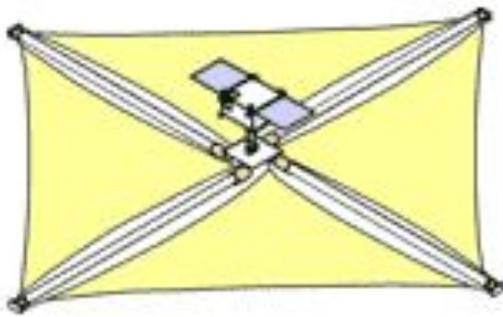
- Interplanetary Transport Network
 - Gravitationally determined pathways that require little energy
- Electric repulsion technology
 - Generate electricity, use electricity to propel matter □ generate thrust
 - Generally low thrust, but can operate for long times
 - Ion drives have already been developed (e.g. Deep Space 1)



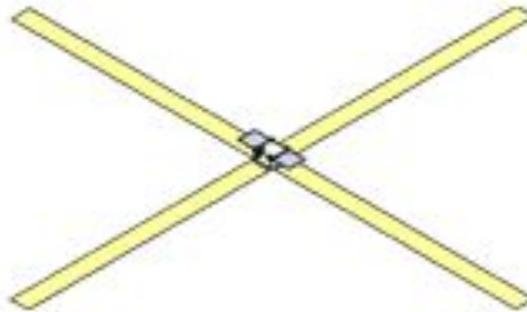
Future of Solar System Travel

- Solar sails
 - Radiation pressure from sun or laser on sail propels craft
 - Some satellites use this technology to make minor flight adjustments
- Nuclear thermal or solar thermal
 - Nuclear or solar power used to heat up fluid which travels through nozzle to create thrust

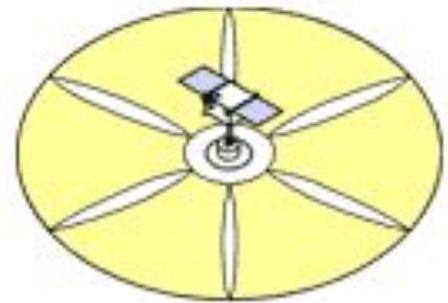




Square Sail (not to scale)



Heliogyro (not to scale)

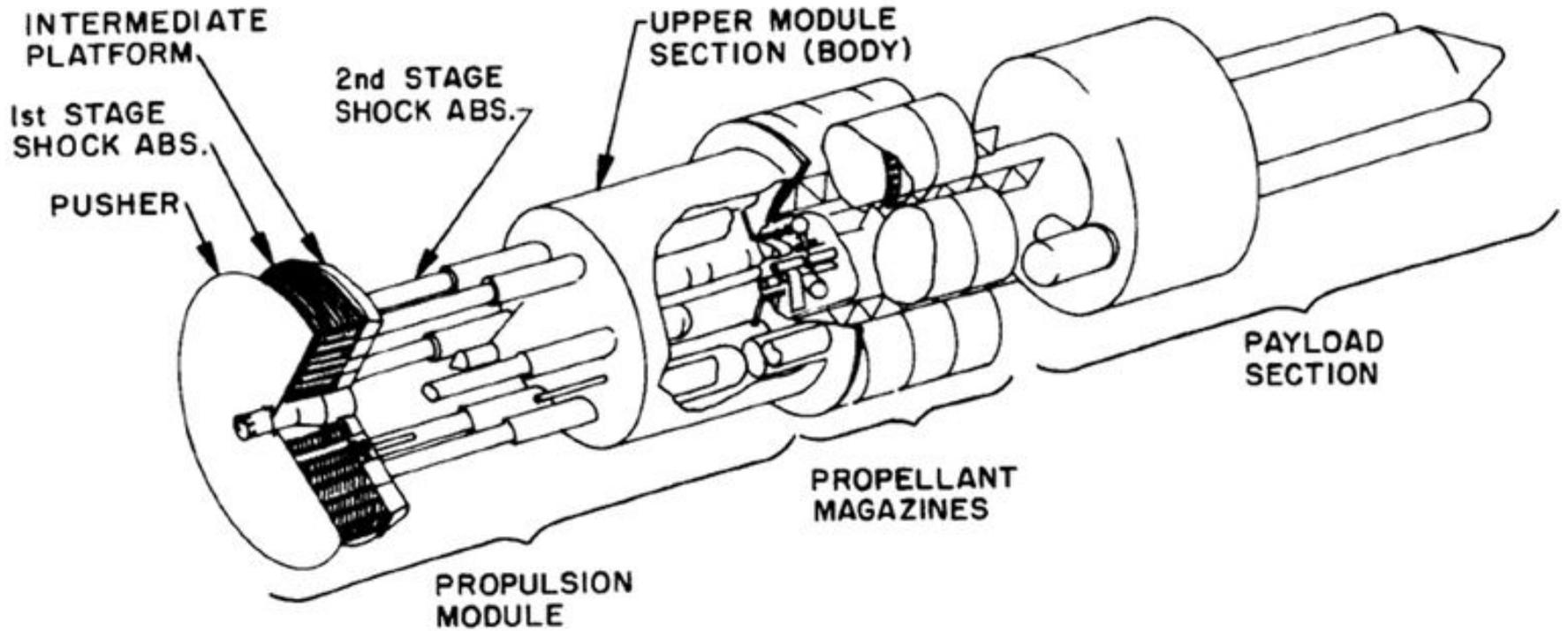


**Spinning Disk Sail
(not to scale)**

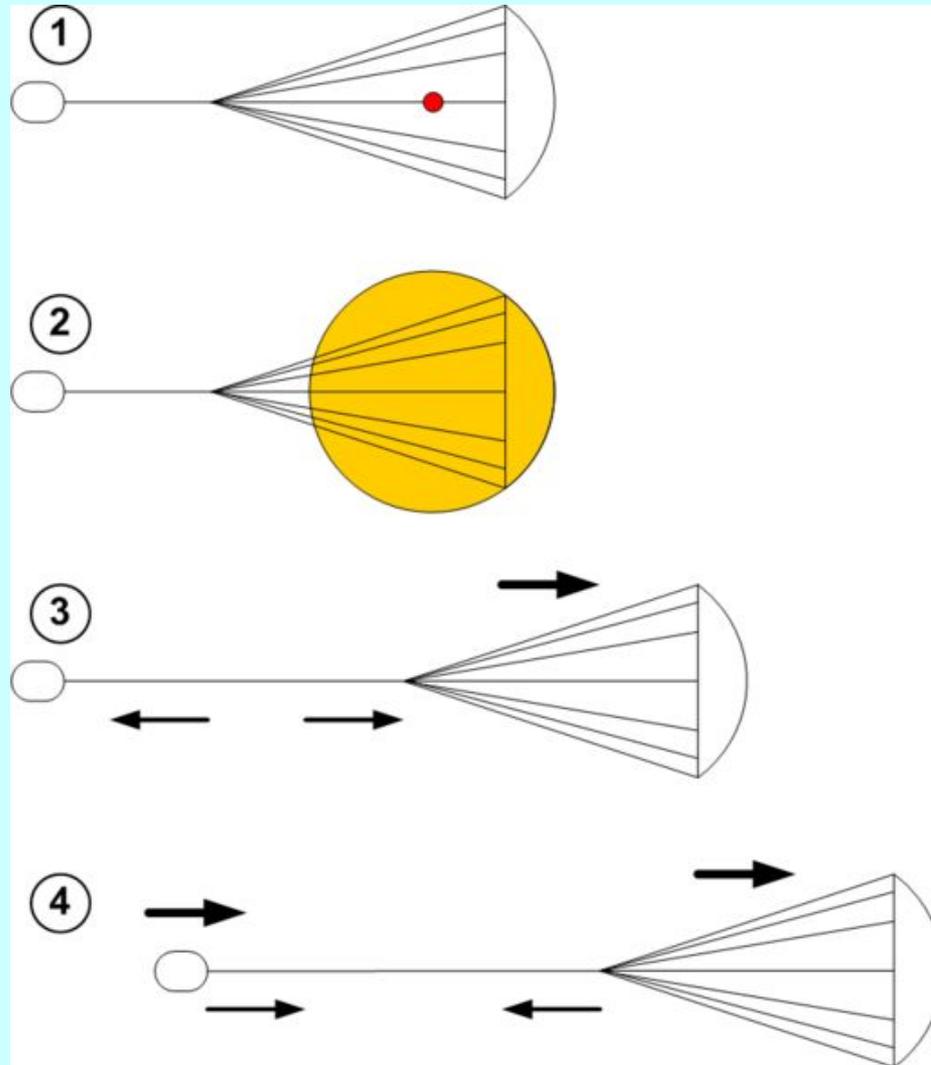
Interstellar Travel

- Closest known star is 4.23 lyr away
- Nuclear Pulse propulsion
 - Driven by series of nuclear explosions
 - Project Orion – would use nuclear bombs as propellant, possible with existing technology
 - Project Medusa – uses large sail to maximize energy deposited by nuclear blast
 - Antimatter Catalyzed NPP – antimatter reduces amount of material needed for fission reaction

Project Orion

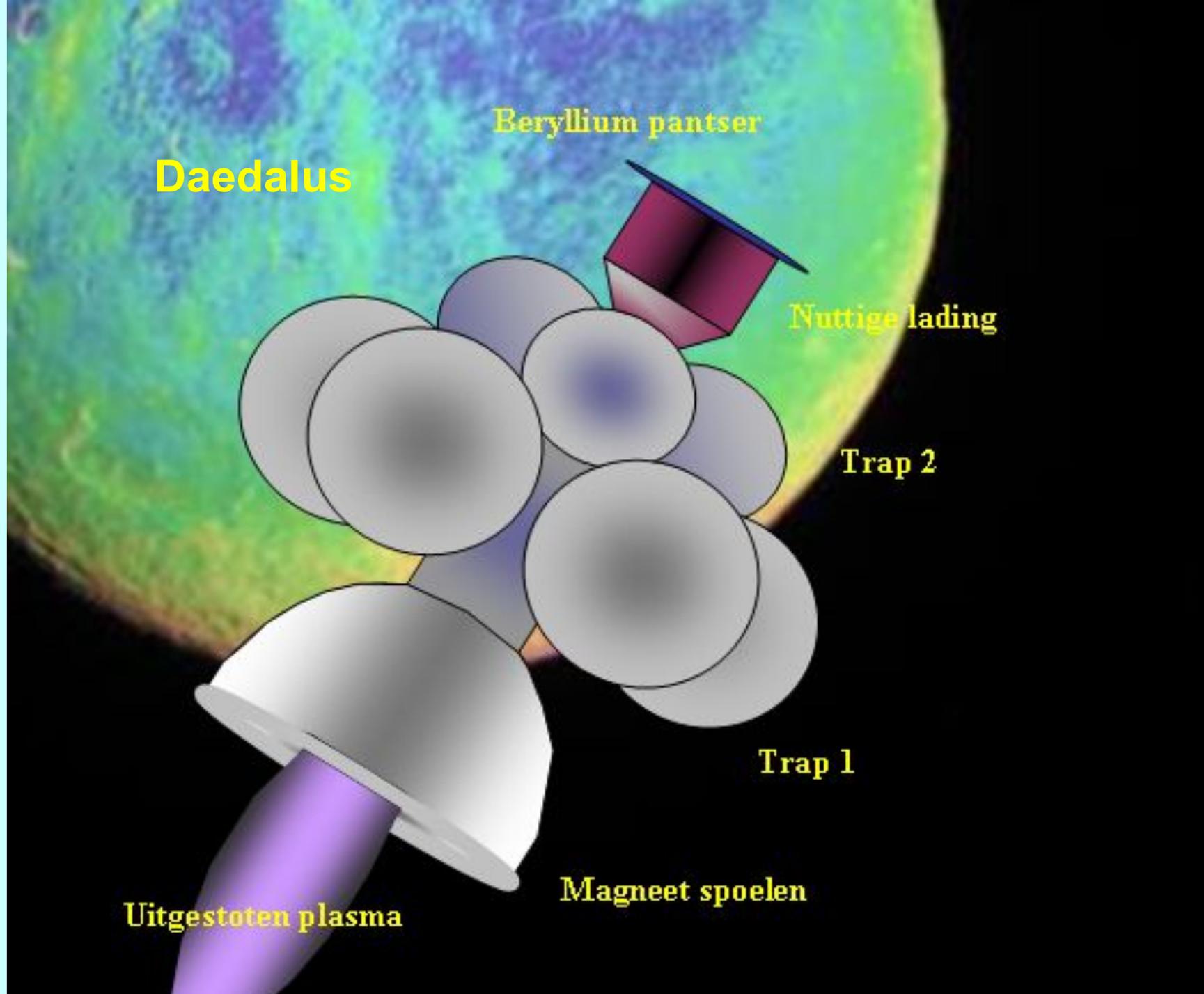


Project Medusa



Interstellar Travel

- Fusion rockets
 - Project Daedalus – laser fuses pellets □ plasma shot out of magnetic nozzle
 - Project Longshot – could reach Alpha centauri in 100 years, travel at 0.045c
 - Need to have fuel source – could possibly scoop it up as you go
- Antimatter rockets
- Beamed propulsion
 - Laser at home propels solar sail
- Hawking radiation propulsion



Interstellar Travel

- Transmission “travel”
 - Transmit information needed to reconstruct a person to distant receiver
- Long trips
 - Hibernation
 - Frozen embryos
 - Extended lifespan
 - Generation ships

Destination	1G	2G	5G	10G	Planetary time
Alpha Centauri	4 years	2.8	1.8	1.3	5
Sirius	7	5	3	2.2	13
Galactic Core	340	244	155	110	30,000

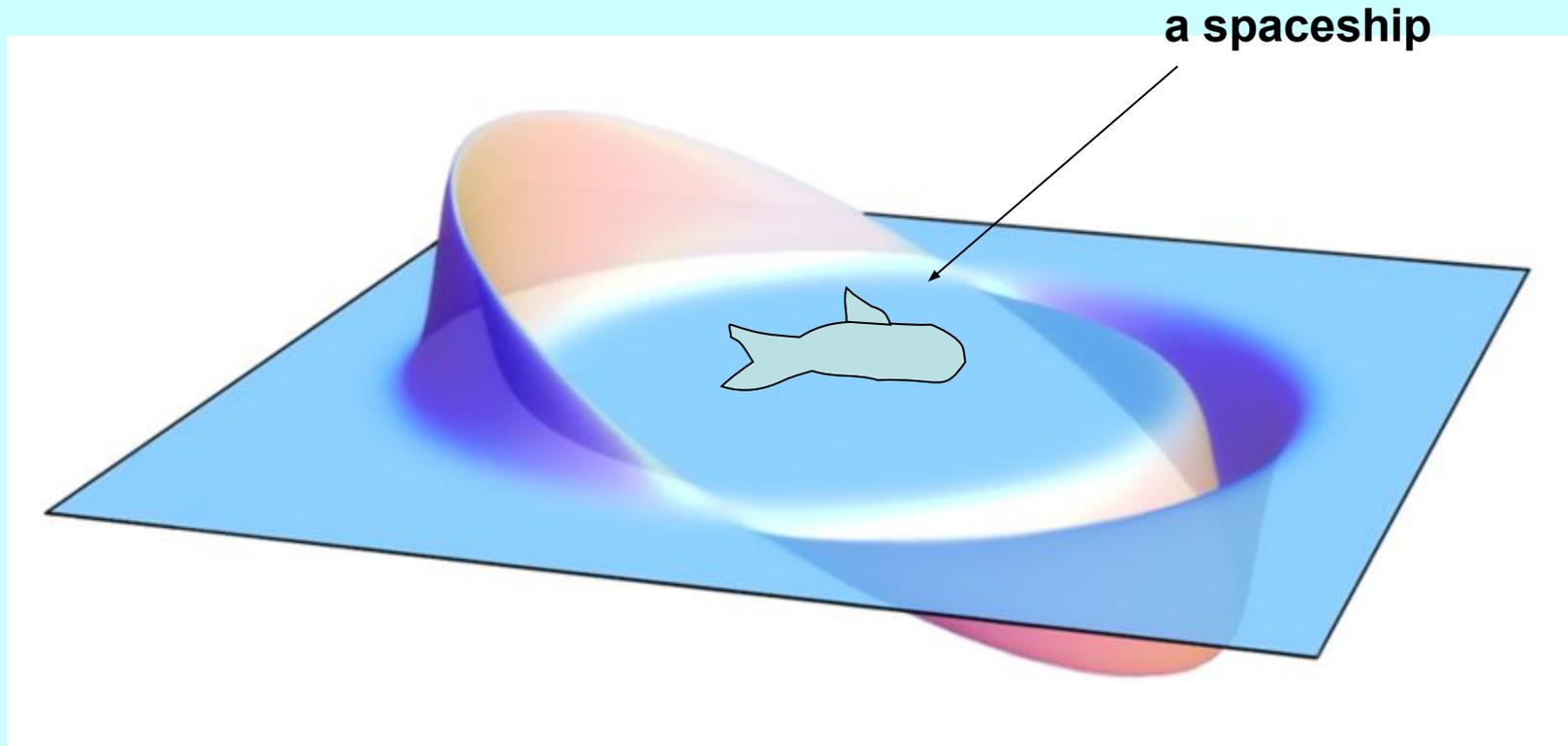
Intergalactic Travel

- 2.54 million lyr between us and Andromeda
- Need essentially light speed technology
- Few realistic proposals

Faster than light travel

- A bubble of space-time that is traveling faster than light does not violate relativity
 - Could place spaceship inside of such a bubble
 - Alcubierre drive
 - Space time wave – spacetime in front expands, spacetime in back contracts
 - Creation would likely require exotic matter
 - Could not be controlled or steered
 - Wormhole
- Still violates causality
 - Quantum gravity may force causality

Alcubierre Drive



Faster than Light Travel

- Vacuum effects
 - “Vacuum” in which c is measured has energy associated with quantum fluctuations
 - By changing vacuum energy, could change speed of light to higher than standard value of c = Scharnhorst effect
 - Casimir effect represents lowering of vacuum energy □ predicted increase in speed of light by 1 part in 10^{36} for plates that are 1 micrometer apart

The End